APPENDIX IXA:

DRAINED (S) REPEATED DIRECT SHEAR TEST

1. INTRODUCTION. The repeated direct shear test is used to measure the residual shear strength of a soil (primarily clay shale material) under drained conditions. In this test, a square soil specimen acted on by a normal stress is repeatedly sheared by reversal of the direction of shear until a minimum, i.e. residual, shear stress is determined. The concept of the test is that a specimen of material is acted upon by normal and shear stresses until, after large shear deformation, disaggregation and increase in parallel orientation of soil particles in the direction of shearing occur and a surface or a thin zone of remolded material is formed. Thus a minimum drained shearing resistance is offered. The shear surface or zone can be formed by (a) shearing an intact specimen, (b) cutting a plane surface through an intact specimen with a fine wire, or (c) shearing a completely remolded specimen. Practical laboratory considerations favor the use of a precut shear plane as it may not be possible to induce a plane surface by shearing an intact stiff-to-hard specimen. Any irregularities of the shear surface would introduce an added resistance that would not be a measure of the shear strength of the material.

2. APPARATUS. The apparatus may be similar to that described in Appendix IX, DRAINED DIRECT SHEAR TEST. A controlled strain device in which the direction of shear is capable of being reversed should be used to apply the horizontal shear force to the specimen.

3. SPECIMEN PREPARATION. a. Specimens should be prepared using procedures similar to those described in Appendix IX, DRAINED DIRECT SHEAR TEST; special saws may be required for trimming stiff-to-hard materials. Special care must be exercised to ensure that the specimen is not subjected to air-drying during or after trimming operations.

b. The specimen should consist of two pieces of intact material trimmed to fill the inside of the shear box or confining ring. The two pieces should be of approximately equal height and have a total height not in excess of 1 in. (preferably, the total height should be 0.5 in., but this is often not practical for stiff, fissured materials). The top and bottom surfaces of each piece should be plane and parallel. A close fit of each piece to the inside of the shear box is necessary. Stiff-to-hard materials may be cut to shape with a bandsaw or, in the case of very hard materials, with a diamond wheel.

c. From the soil trimings obtain about 200 g of material for water content and specific gravity determinations (see Appendix I, WATER CONTENT - GENERAL, and Appendix IV, SPECIFIC GRAVITY).

4. PROCEDURE, a. Preliminary. The procedure for setting up the test specimen shall consist of the following:

(1) Record all identifying information for the specimen, such as project title, boring number, sample number, and other pertinent data, on the data sheet (Plate IX-l is a suggested form); note any difficulties encountered in preparation of the specimen. Determine the dimensions of the specimen and record as the initial dimensions of the specimen on the data sheet. Weigh and record the weight of specimen (plus tare, if used).

(2) The lower half of the specimen should be firmly seated against a saturated porous plate in the lower half of the shear box. A 0.010- to 0.020-in. projection of the lower half of the specimen above the lip of the box is desirable; certainly the top of this half of the specimen should not be initially below the lip. Then the upper half of the specimen should be placed in the shear box, the upper porous plate (saturated) added, and the remainder of the shear apparatus assembled.

A specimen of softer material may be precut inside the shear box. In this case, an intact specimen is firmly seated between saturated porous plates in the apparatus ; then, a plane should be cut with a small-diameter (0.008- to 0.014-in. diameter) steel wire through the specimen at the separation between the upper and lower halves of the box. After cutting, the two halves of the specimen should be separated, and the cut surfaces inspected for planeness. Any irregularities should be removed with a straightedge.

(3) Place the shear box in position on the loading apparatus. At this time the upper and lower frames are in contact. Assemble the loading equipment and mount the two dial indicators or other deformation measuring apparatus to be used for measuring vertical and horizontal deformation. Both indicators should be set so that they can measure deformation in either direction.

b. Consolidation, The procedure for consolidating the specimen shall consist of the following:

(1) Apply the normal stress to the specimen without impact. A single value of normal stress may be used. A standard value of about 6 tons per sq ft is recommended as being high enough to prevent the swelling of most clay shale material yet low enough to minimize the problem of soil extruding from between the two halves of the box during shear. In addition, tests under higher normal stresses may be used to determine whether the strength envelope is a straight line.

(2) As soon as possible after applying the normal stress, fill the water reservoir with distilled or demineralized water to a point above the top of the specimen. Maintain this water level during the consolidation (or swell) and subsequent shear phases so that the specimen is at all times effectively submerged.

(3) The specimen should be allowed to consolidate or swell to an essentially equilibrium condition under the normal stress; a minimum period of 16 hr should be allowed before shear.

c. Repeated Shear Test. The procedure for shearing the specimen after consolidation shall consist of the following:

(1) A gap should be formed between the two halves of the box to ensure that normal and shear stresses are borne only by soil. This

gap should be kept between 0.015 to 0.025 in. to minimize extrusion of remolded soil from the shearing surface. Periodically during the test, the gap should be checked by inserting thickness gages, and adjusted as needed.

(2) Remove the alignment pins.

(3) Shearing displacement should be initiated at a controlled rate not in excess of 0.5 in. per day (about 0.00035 in. per min). Shear movement under constant normal stress should be continued with a reversal of direction after about 0.25-in. displacement to each side of the starting position until a minimum shearing resistance is attained. A semilogarithmic plot of shear stress (arithmetic scale) versus cumulative shear displacement (logarithmic scale) should be maintained during the test to show when a minimum value has been reached; only the shear stress measured at the midpoint of each shearing stroke (that is, when the two halves of the shear box are aligned vertically) should be plotted.

(4) Observations of vertical and horizontal deformations and the applied shear force sufficient to define the stress deformation curve for each shearing stroke shall be made.

(5) If, after the standard test is complete, the effects of increased normal stress and decreased displacement rate are to be studied, this information should also be obtained according to uniform procedures.

First, the normal stress should be doubled while the two halves of the shear box are vertically aligned, and the specimen should be permitted to come to equilibrium (minimum of 16 hr). Shear displacement should be initiated at a rate of about 0.5 in. per day and continued until a minimum shearing resistance is reached.

Second, the effect of decreased rate of displacement should be determined as follows. After the minimum shearing resistance is reached under the high normal stress (approximately 12 tons per sq ft) and at a displacement rate of about 0.5 in. per day, the rate of displacement should be reduced to a tenth of the standard rate (that is, to about 0.05 in. per day) without any change in the normal stress. The rate of displacement should be reduced soon after the upper half of the shear box has passed through the initial, vertically aligned position. Shearing with repeated reversals of direction as described above should be continued until a minimum shearing resistance is reached.

(6) Remove the specimen from the shear box, blot any excess moisture, and determine the water content of the specimen† (see Appendix I, WATER CONTENT - GENERAL). The dry weight of the specimen should be computed using the water content based on specimen trimmings taken during specimen preparation.

5. COMPUTATIONS. See Appendix IX, DRAINED (S) DIRECT SHEAR TEST.

6. PRESENTATION OF RESULTS. Report forms have not been standardized; the method of presentation of results will be determined by the project (design) engineer requesting the tests.

7. POSSIBLE ERRORS. The following are possible errors that may cause inaccurate determinations of strength and stress-deformation characteristics:

a. Air -Drying of Specimen During Preparation. The trimming of specimens should be done in a humid room with every precaution taken to prevent change in natural water content. Air-drying may cause the specimen to slake readily when inundated with water, and thus change the strength or stress-deformation characteristics.

b. Top and Bottom Surfaces of Each Half of a Specimen Not Plane and Parallel. Irregular surfaces may introduce a geometric component to the measured shearing resistance.

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† If considerable remolded material exists in the shear zone, it should be removed and its water content should be determined in addition to that of the remainder of the specimen.

c. Too Large a Gap. Maintaining too large a gap between the upper and lower frames of the shear box may result in excessive extrusion of the specimen.

d. Absence of Gap. A gap must be maintained throughout the test to prevent the normal load from being borne by the lower frame of the shear box.

e. Inaccurate Measurement of Shear Stress. Because of the very small shear resistances offered by some clay shale materials, measurement of shear stress must be very precise.

f. Permeability of Porous Stones Too Low. Unless the porous stones are frequently cleaned, they may become clogged by soil particles and ingress or egress of water to or from the specimen may be inhibited.

g. Galvanic Action in Shear Box. To prevent any change in the strength or stress-deformation characteristics due to galvanic currents in tests of long duration, all metal parts of the shear box should be constructed of the same noncorrosive material.

h. Stopping Test Too Soon. The test must be carried to a cumulative shear deformation sufficient to establish that the minimum shear resistance offered by a specimen under a given normal stress has indeed been determined. A semilogarithmic plot of shear stress (arithmetic scale) versus cumulative shear displacement (logarithmic scale) is essential in making this determination.